

December 18, 2018

Smoky Canyon RI/FS Modeling

Se Transport to Hoopes Spring

Topics

- RI Model Review
 - Development Group
 - Modeling Objectives
 - Site-Wide Modeling Process
 - GIS/Source Term Model
 - Analytical Model
 - North- & South-End Models
- FS Model
 - Updates from East Smoky PDEIS
 - Lysimeter data
 - Source term
 - Results
 - Groundwater pathway
 - Travel time to Hoopes
- Path Forward

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1567840

RI Model Review

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Model Development Group

280) ...The word "objects" should be "objectives."
281) ...The sentence is missing the word "of" between the words "source" and "selenium."
282) ...Please edit the phrase "Time for pore volume to infiltrates...."

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- March 2012 - April 2014
- Attendees
 - Agencies & reps
 - Tim Mosko, Gerry Winter, Matt Wilkening
 - Brady Johnson & Mary Kauffman
 - Simplot
 - Monty Johnson and Lori Hamann
 - Formation
 - Pete, Buz, Bronwyn, Fred, and Lily
- Progressive understanding as complexities incorporated or assumptions evolve
 - Review inputs and assumptions
 - Address concerns as appropriate
 - Discuss updates to the model
 - Three editorial comments on RI reporting (App H)

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Modeling Objectives

- Quantify source area contributions to Springs Complex
 - Panels A, B, C, D, E
 - Pole ODA
- Represent Site conditions changing over time and subsequent selenium transport
 - Active mining
 - Reclamation
 - Removal Action(s)

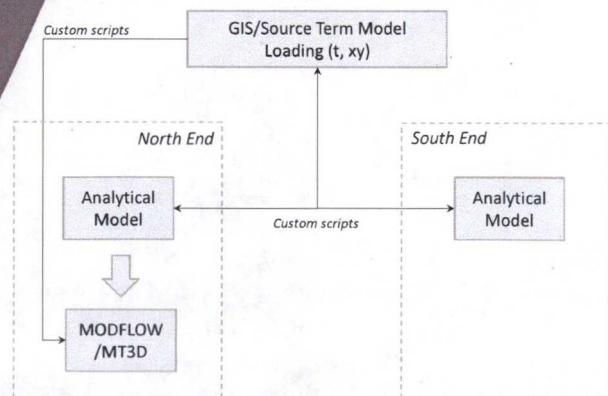
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Site-Wide Modeling Process

- South-end is flow system reporting to Springs Complex
- North-end is hypothetical northerly flowpath
- Model development focused on South-end
- North- and south-end models are based on the same GIS/Source Term Model

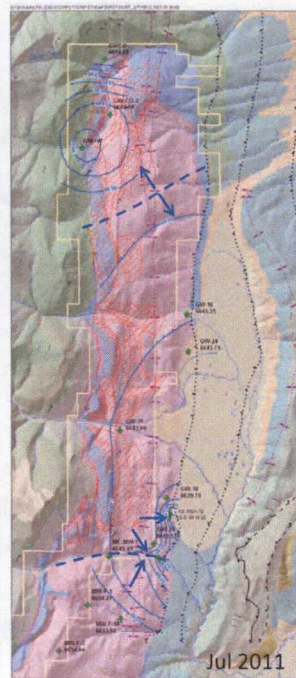
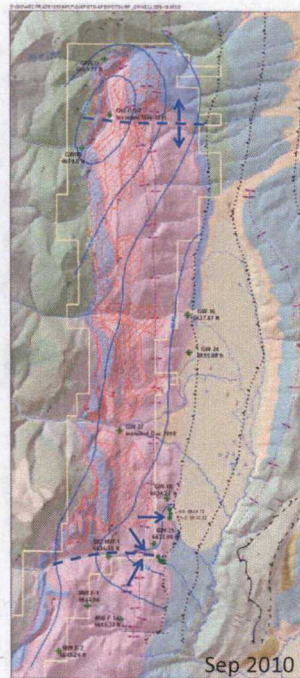
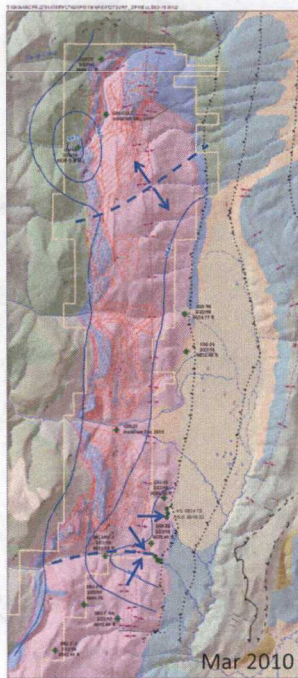


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Model
Development
Group, circa
1/23/2014



North end



South end

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Time varying:

- ROM backfill
- Storm water
- Reclamation/cover type

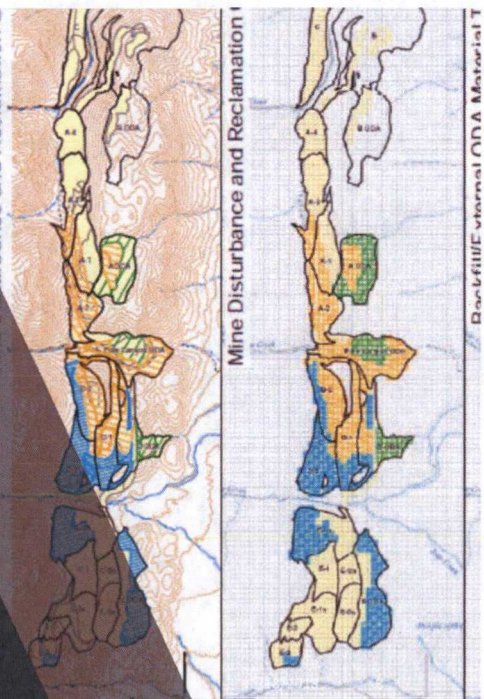
GIS/Source Term

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Mine Disturbance and Reclamation L

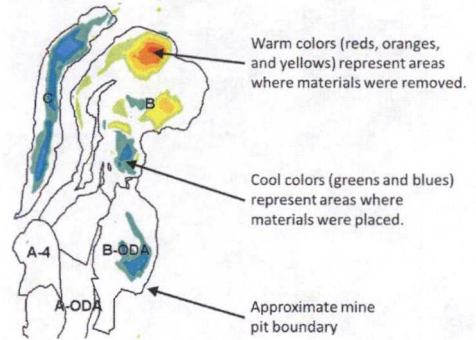
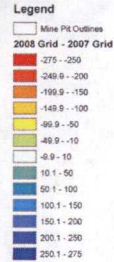
Mine Disturbance and Reclamation I

Backfill/E stormal ODA Material T



Backfill Sources

- Data sources:
 - Annual Operations Reports
 - Elevation data
 - Aerial images
 - Historic CAD drawings
- Identification of Backfill Sources Using Elevation Differences



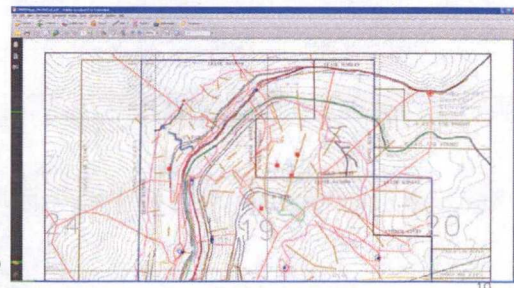
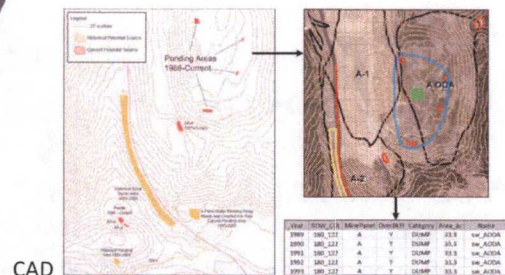
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Storm Water Sources

- Data sources:
 - CAD drawings of Areas of Enhanced Infiltration provided by Mine personnel
 - Stormwater Pollution Prevention Plan (SWPPP) maps
 - Annual contours (watershed analysis)
 - Discussions with Mine personnel
 - Geophysical studies (Willowstick Investigations)



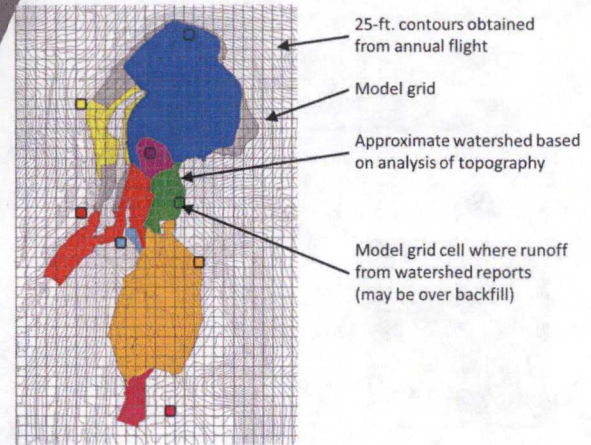
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Watershed Analysis

- GIS-based analysis
- Estimate of run-off
- Run-off to ROM?
→ Se source to groundwater



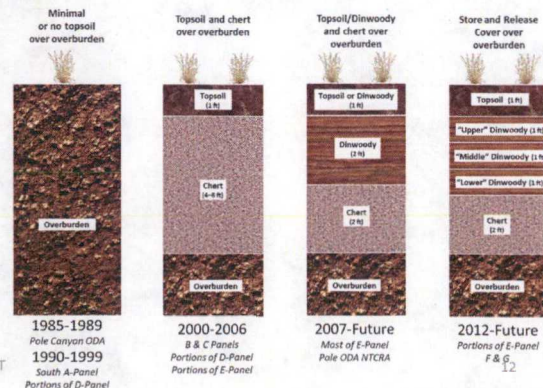
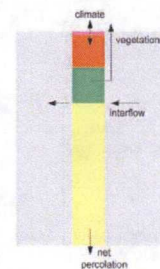
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Infiltration Modeling

- Simulate the water balance, by year, for each cover type (net percolation)
- "Net percolation" – the infiltrating water that migrates beyond the active zone and into the underlying waste

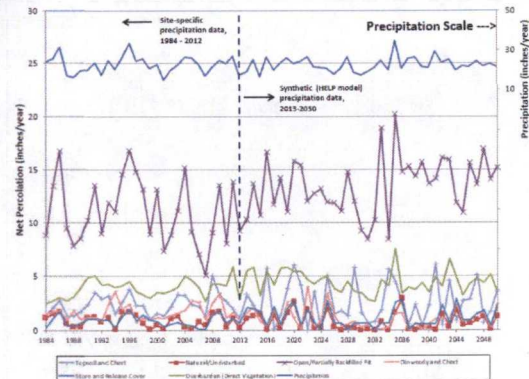


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Land Use/Cover Types

- Open pit
 - Partially backfilled (unvegetated, no runoff)
- Covers (vegetated & unvegetated)
 - Backfilled pit/ODA (overburden only)
 - Topsoil (0-6 in), overburden
 - Topsoil (1 ft), chert (6 ft), overburden
 - Dinwoody (3 ft), chert (2 ft), overburden
 - Topsoil (1 ft), Dinwoody (2 ft), chert (2 ft), overburden
 - "Store and Release Cover" – Topsoil (1 ft), Dinwoody (3 layers at 1 ft each), chert (2 ft), overburden



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Climate Data

- Temperature
 - Slug Creek/Smoky Guard Shack regression (1984-2004)
 - Smoky Guard Shack Automated (2005-2010)
 - Bully Barn (2011)
 - Slug Creek/Smoky regression (2012)
- Relative humidity, wind speed – NOAA Pocatello
- Solar radiation – calculated based on latitude
- Precipitation
 - Smoky guard shack
 - Automated daily (2005-June 2011)
 - Manual monthly (2000-present)
 - Slug Creek Divide NRCS SNOTEL
 - Automated daily (1984 to present)
 - Monthly sums not to exceed manual Smoky data

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Infiltration Model Output

- Estimate for each cover type for each year
 - 1984 – 2015
 - 2016 – 2050 (synthetic)
- Summarized in lookup table

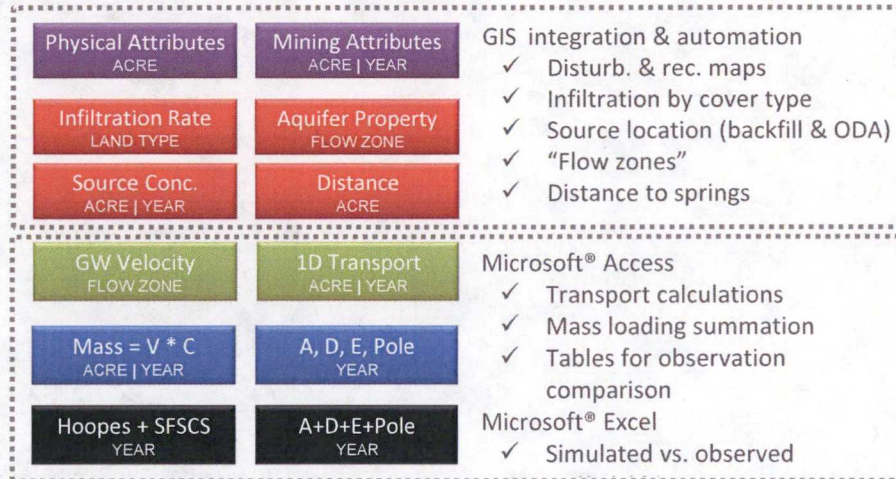


- Analytical Model
 - GIS (location, time, presence of backfill)
 - Infiltration (location, cover type, rate)
 - Source term (time and load)
 - Transport to springs

Analytical Model

- GIS "integration & automation"
 - Link to yearly mine disturbance and reclamation info
Maps → GIS → Model → Predictions
 - Location of sources areas thru time
 - Infiltration by cover type thru time
 - Enhanced infiltration (location and volume)
- Infiltration Modeling
 - HELP, VADOSE/W
 - Infiltration rates by cover type thru time
- 1-D Transport
 - Smoky's unique groundwater setting allows the use of a less complex modeling approach
 - Transport from source areas to the Springs Complex
 - Se loading at Springs Complex
 - Se concentration at Springs Complex

“Analytical Model”



“ACRE” = 1 acre grid cell
“YEAR” = Model attributed on yearly time period

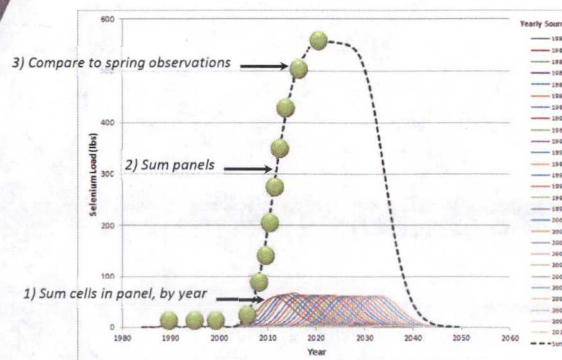
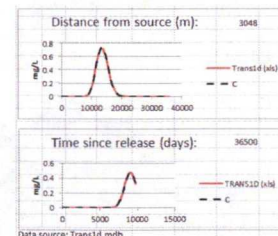
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Transport Methodology

- Saturated flow, 1-D transport
 - Van Genuchten and Alves (1982)
 - Continuous or finite source
 - Linear sorption, first order degradation
 - Developed by H. Dawson (Co. School of Mines, EPA)
- Formation implementation for Smoky
 - Verified against Dawson’s solution
- Grid-based (1-acre grid cells)
- For each source cell (backfill and ODA), each year
- Inputs
 - Velocity K^*i/n_e (site data, calibration)
 - Dispersivity (literature, calibration)
 - Adsorption (conservative)
 - Distance
 - Source concentration (column test, time)



Mass Arrival at Springs Complex 18

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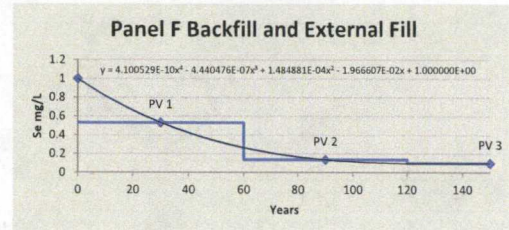
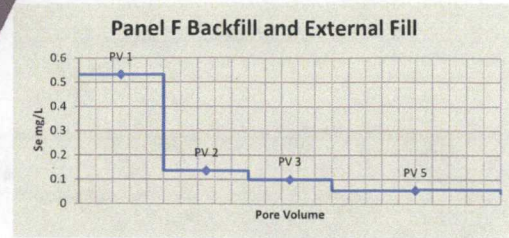
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Source Term

- Concentrations based on column tests
- Convert pore volume (PV) to time consistent with F&G EIS
- Time pore volume infiltrates through overburden
 - $\text{Volume} * \text{Porosity} * \text{Pref. Flow Factor} / \text{Infiltration rate}$
- Key Assumptions
 - All overburden is run of mine (ROM) mix
 - All overburden sources are average thickness
 - Time is dependent on infiltration rate

Example:

$\text{Volume} * \text{Porosity} * \text{Pref. Flow Factor} / \text{Infiltration rate}$
 $100 \text{ ft} * 0.3 * 0.5 / 0.25 \text{ ft/yr} = 60 \text{ years}$



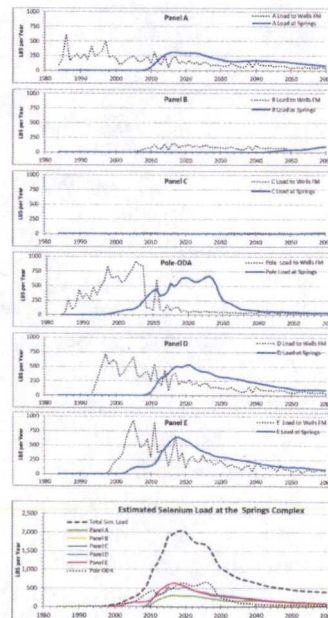
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Analytical Model

- Estimate of relative contribution of selenium loading by panel
- Total loading at spring complex



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RI North-End Model

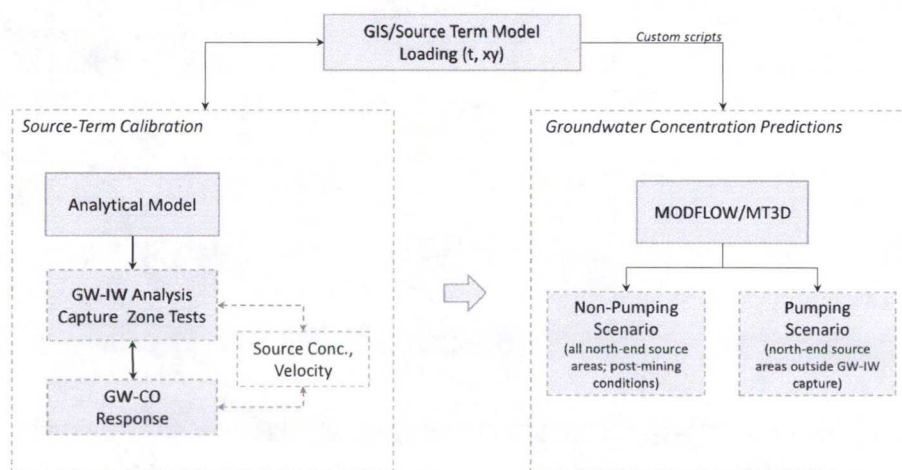
[East Smoky PDEIS indicates southerly flow]

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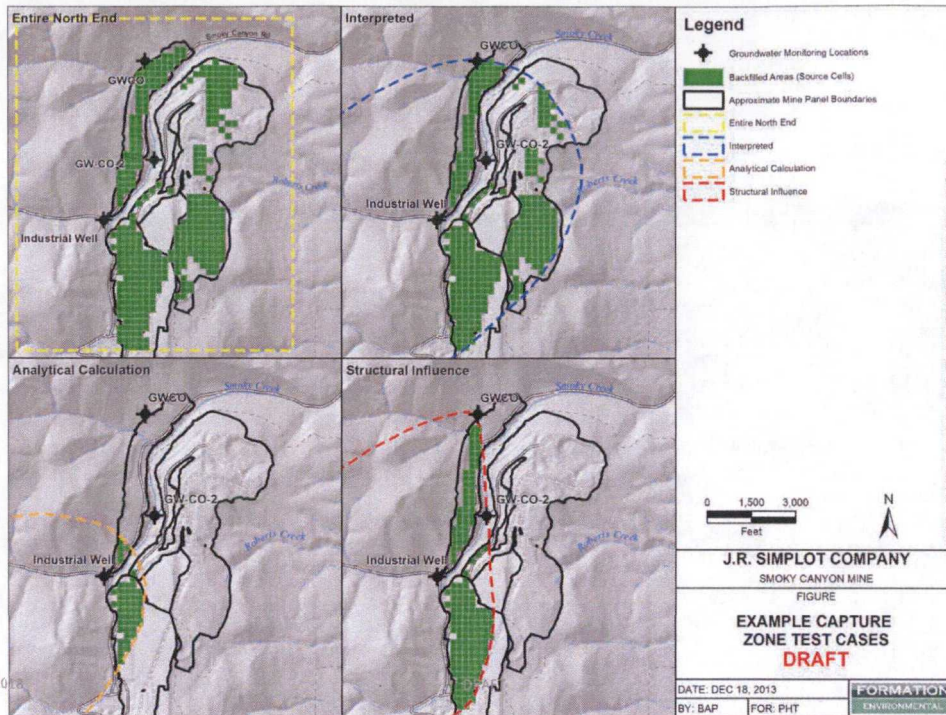
RI North-End Models



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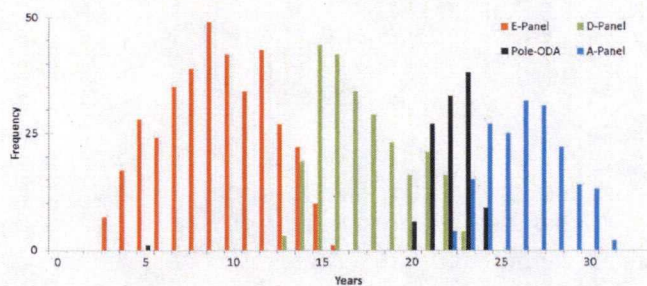


RI South-End Model

RI Analytical Model Results

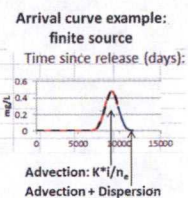
Travel time to Springs Complex
for all source cells

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Based on advective velocity = K^*i/n_e

Note: transport model accounts for
velocity and dispersion



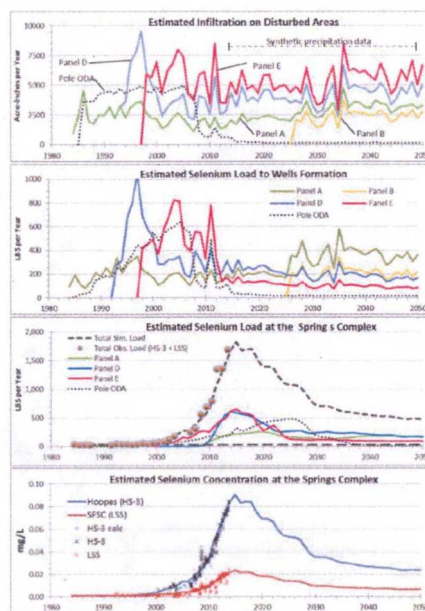
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RI Analytical Model Results

Infiltration
Load to Wells Formation
Load at Springs
Concentration at Springs

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FS Model

All Wells FM groundwater reports to the springs complex,
less capture at Industrial Well

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Updates from East
Smoky PDEIS
(assures
consistency)

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- Southern flow regime definition
- Capture zone/timing of industrial well pumping
- Transport velocity consistency
 - East Smoky \approx Analytical model
 - \approx 30-year transport time from northern area to Hoopes Spring
- Panel B/C source-term verification

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B/C Source term verification

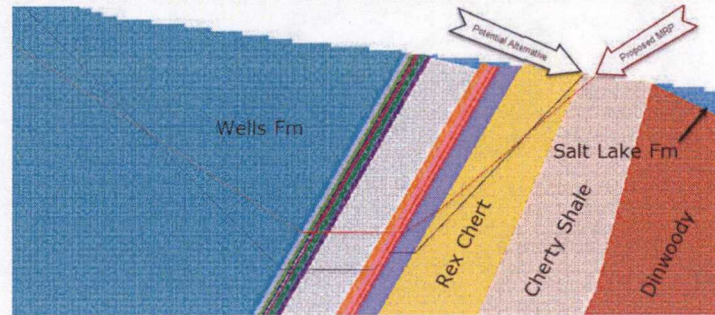
East Smoky backfill << B/C

Source term assumption is high

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Mine	Area/Alternative	Column	Tested Material	Selenium in leachate (mg/L)			
				PV-1	PV-2	PV-3	PV-4
East Smoky Panel ¹	Proposed Action	ROM-U1	Run-of-Mine (ROM) Backfill	0.076	0.006	0.0031	0.0021
	Reduced Pit Shell	ROM-WA	Weighted Average	0.0526	0.0081	0.0062	---
	Panels B&C ²	ROM	ROM Backfill	0.181	0.064	0.047	---
Smoky Canyon	Panel F ³	ROM	Backfill and External Fill	0.532	0.136	0.1	0.095
	Panel G ³	ROM	Backfill	0.64	0.119	0.067	0.087
	Panel G ³	ROM	External Fill	0.799	0.138	0.078	0.048

Figure 3. Generalized Cross Section Comparing the Proposed Action Pit Shell to a Potential Alternative



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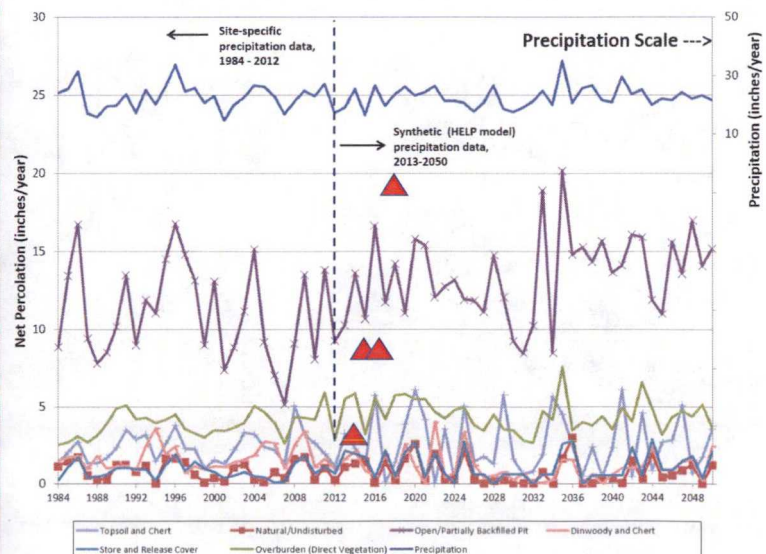
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Lysimeter Data

RI Percolation Rates and Precipitation,
Water Year Measured Percolation

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Deep Dinwoody Lysimeter, Water Year 2014-2017



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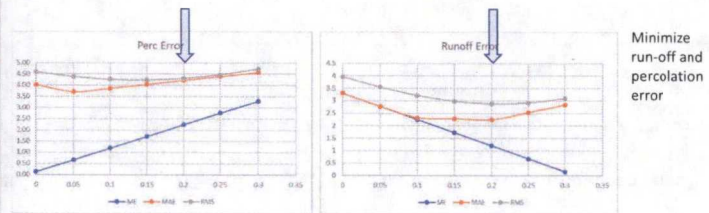
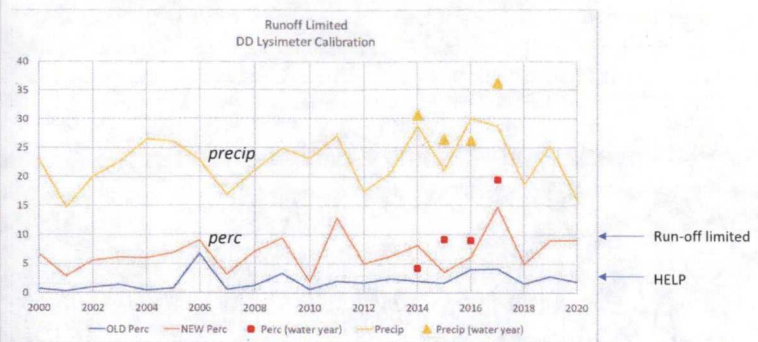
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Lysimeter Data

HELP overpredicts run-off
Deep Dinwoody perc adjustment
based on run-off limit from
lysimeter data

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Deep Dinwoody Lysimeter, Water Year 2014-2017



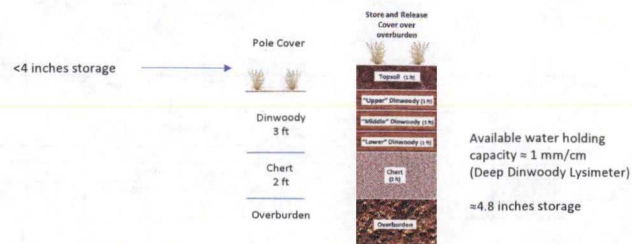
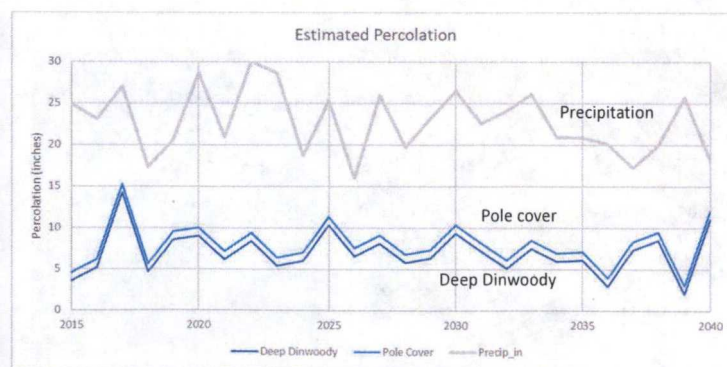
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Lysimeter Data

Cover performance scaled to
Deep Dinwoody based on relative
"storage capacity"

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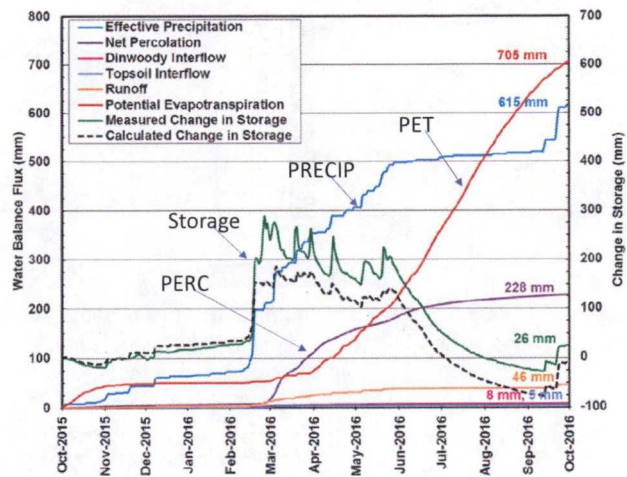
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Storage Capacity

High level summary

- Deep Dinwoody store and release
 - Designed with low permeability layer
 - Low K layer evolved thru wetting and drying... $1e-6 \rightarrow 2e-5$ cm/s
 - No longer permeability limited
 - Perc limited by storage capacity of "fines"
- Pole is perc limited by storage capacity
- "Storage capacity"
 - Hold water during periods of no ET

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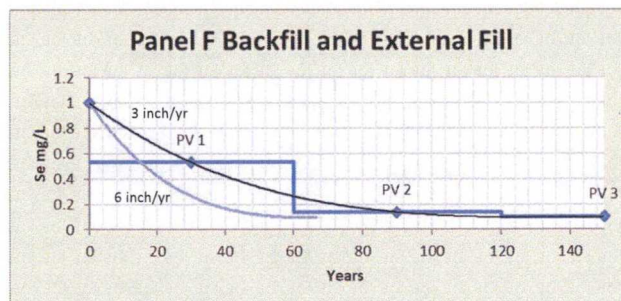
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Source Term

Consistent with EIS modeling,
Depletion dependent on
percolation rate

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Column leach results: Concentration per pore volume

Modeling \rightarrow pore volume to time:

Avg. overburden thickness / rate = time
(Thickness x Porosity x Preferential Flow) / Infiltration = years

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EPA (2002) Soil to Groundwater Pathway

Simple, screening level model



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Equation 4-11 Derivation of Dilution Attenuation Factor

$$\text{Dilution Attenuation Factor (DAF)} = 1 - \frac{K \times i \times d}{I \times L}$$

Parameter/Definition (units)	Default
DAF/dilution attenuation factor (unitless)	20 or 1 (0.5-acre source)
K/aquifer hydraulic conductivity (m/yr)	Site-specific
i/hydraulic gradient (m/m)	Site-specific
I/infiltration rate (m/yr)	Site-specific
d/mixing zone depth (m)	Site-specific
L/source length parallel to ground water flow (m)	Site-specific

4-28

Equation 4-12 Estimation of Mixing Zone Depth

$$d = (0.0112L)^{0.5} \times d_a(1 + \exp[(K \times i) \times d_a])$$

Parameter/Definition (units)	Default
spth (m)	Site-specific
parallel to ground water flow (m)	Site-specific
(m/yr)	Site-specific
K/aquifer hydraulic conductivity (m/yr)	Site-specific
i/hydraulic gradient (m/m)	Site-specific
d/aquifer thickness (m)	Site-specific

United States
Environmental Protection
Agency

Solid Waste and
Emergency Response

OSWER 9305.4-24
December 2002

Superfund

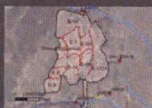
EPA SUPPLEMENTAL GUIDANCE FOR DEVELOPING SOIL SCREENING LEVELS FOR SUPERFUND SITES

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EPA (2002) Soil to Groundwater Pathway

Simple, screening level model



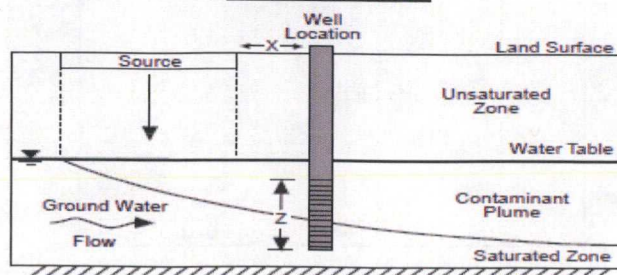
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Mixing model to estimate Dilution and Attenuation Factor

Conservative, simplified assumptions :

- Infinite source
- No contaminant attenuation
- Homogeneous and isotropic hydrologic properties
- "Receptor well" at the down gradient edge of the source and screened within the plume.

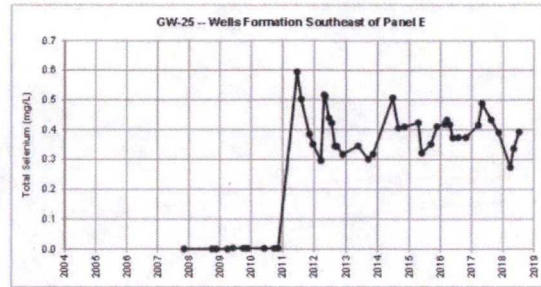
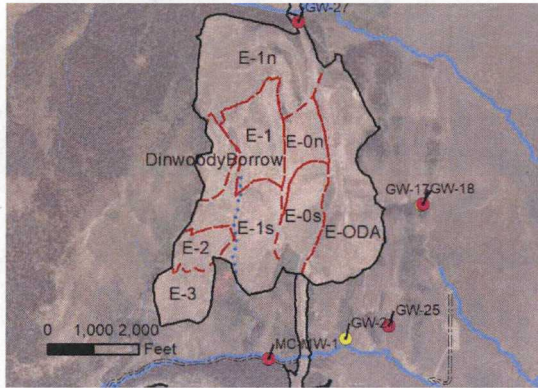
SECTION VIEW



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GW-25



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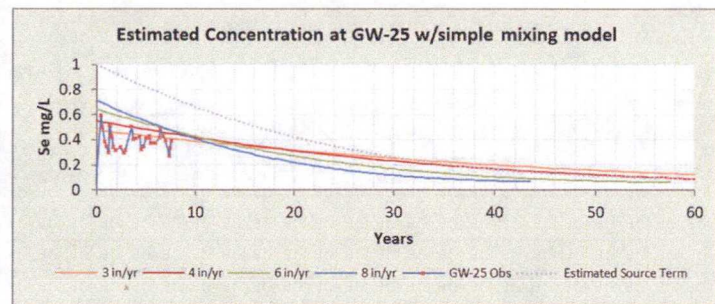
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Groundwater Pathway

Simple mixing model
Applied at GW-25 with Panel E sources

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- Groundwater concentrations at GW-25 suggest infiltration ≈ 4 in/yr
- One line of evidence that lysimeter data are over estimating long-term percolation

Mixing Factor

in/yr	DAF
8	1.4
6	1.55
4	1.82
3	2.1

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Summary of Model Update

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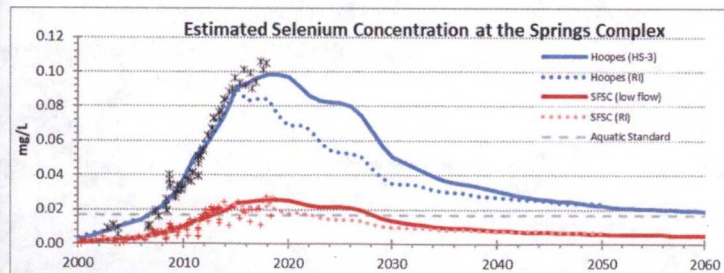
- Incorporated site specific data from East Smoky
- Incorporated Deep Dinwoody lysimeter data
- Evaluated consistency with recent groundwater and surface water data

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RI & FS Models

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